A Web-Based Information System for Agricultural Machinery Use Cost Analysis

A Web-Based Information System for Agricultural Machinery Use Cost Analysis

Alessandro Sopegno [a,*], Angela Calvo [a], Remigio Berruto [a], Patrizia Busato [a] , Dionysis Bochtis [b]

[a] DISAFA, University of Turin, Largo Braccini 2, 10095 Grugliasco (TO) Italy

[b] Department of Engineering, University of Aarhus, Inge Lehmanss Gade 10, Aarhus, Denmark

* Corresponding author. Email: alessandro.sopegno@unito.it

Abstract

Agricultural machinery has the highest resources cost contribution in farm businesses. Moreover, in the last years high in power and size machines, new technologies, higher prices for spare parts, and energy consumption contributed to the rising of the machinery direct and indirect cost. The potential of having an estimation of such cost beforehand is a critical factor for strategic and tactical decision making. However, available web-based applications for agricultural machinery cost estimation are lacking of a mobile application module. The aim of this work is to present the development of an easy-to-se mobile app, to determine the actual machinery cost in different field operations and makes them available via web mobile application using a cross-platform approach. The web mobile app was built using HTML language for the content, JavaScript for the logic part, and CSS as a presentation style. To accelerate the development, the jQuery Mobile (JQM), a touch-optimized JavaScript library, was used. The web mobile app allows the analysis of traction costs and operation costs. The tool is free, readily available and does not require any installation on the end-users mobile devices.

Keywords: agricultural machinery costs, agricultural mobile app, agricultural operation cost

1. Introduction

In the agricultural sector there is a slow adoption in the use of mobile technology (Xin et al. 2015). It has been demonstrated that machinery and equipment are major cost items in farm businesses in different countries (Bochtis, Sørensen, and Busato 2014). The cost of machinery remains a significant portion of the cost of production of a farm for many operations and continues to be one of the highest input costs for farmers (Buckmaster 2003). Many engineering and economic methods have been implemented to calculate machinery use and cost, but they are almost confined in scientific and technical documentations making it difficult for a farmer to apply these methodologies for deciding on buying, leasing, or sharing agricultural machinery. The possibility to know in advance such costs is strategic for the farmers, but the agricultural machine cost determination available by internet applications e.g. (Busato and Berruto 2014) are lacking of a mobile app.

The aim of this work was to develop an easy-to-use mobile application (app), namely Agricultural Machine App Cost Analysis (AMACA) for determining the machinery costs in different field operations and makes it available via a web mobile application using a cross-platform approach. The design process for the AMACA development considered the individual users' requirements (end-users, farmers, contractors, consultant and machinery dealers.

2. Materials and Methods

The methodology of quality function deployment (QFD) has been followed in this process. QFD is one of the most common customer-driven tools of total quality management process linking the user expectations with the design characteristics of the product (Carnevalli and Miguel 2008; Chan and Wu 2002). The general steps of the QFD (which include: users identification, users requirements extraction, users requirements prioritization, design parameters identification, determination of relationships between users requirements and design parameters and correlation between design parameters) were reached with surveys during the agricultural machinery fairs in February and October 2014 in Verona, Italy, and Cremona, Italy, respectively. In total 68 people were interviewed.

Machinery cost determination (fixed and variable) were calculated as suggested by ASABE (2009). Typical speeds and field efficiencies were obtained by Table 3 of ASAE Standards, (2009) and AMACA referred to it for parameters range. Both the working speed and the tools width were used to calculate the draft force required to the tractor by the equipment to accomplish the field operation and to evaluate the operation cost per hectare.

For making the web mobile app AMACA we used HTML language for the content part, JavaScript for the logic, and CSS as a presentation style. We also used a touch-optimized JavaScript library: the jQuery Mobile (JQM). The JQM framework provides many features to support JavaScript basic library. HTML5 local storage feature was used to store some variables which can be modified by the user and are introduced as new parameters for calculations.

3. Results and Discussion

The results of QFD analysis conditioned both software development and graphic user interface (GUI). The design parameters referring to use of input values range, skimmable text, touch friendly interface, text readable on any size of monitor, dashboards practices in the results, multi-language menus, software interoperability, hardware interoperability, no installation need and use of open source encoding were realized.

The app is composed by two main interface pages: Input and Results. Each page shares the same navigation header for a quick switching between the pages and the footer. History tracking and back button is also enabled on each page.

Input page is divided into two sections: tractor data and machinery data (Figure 1).

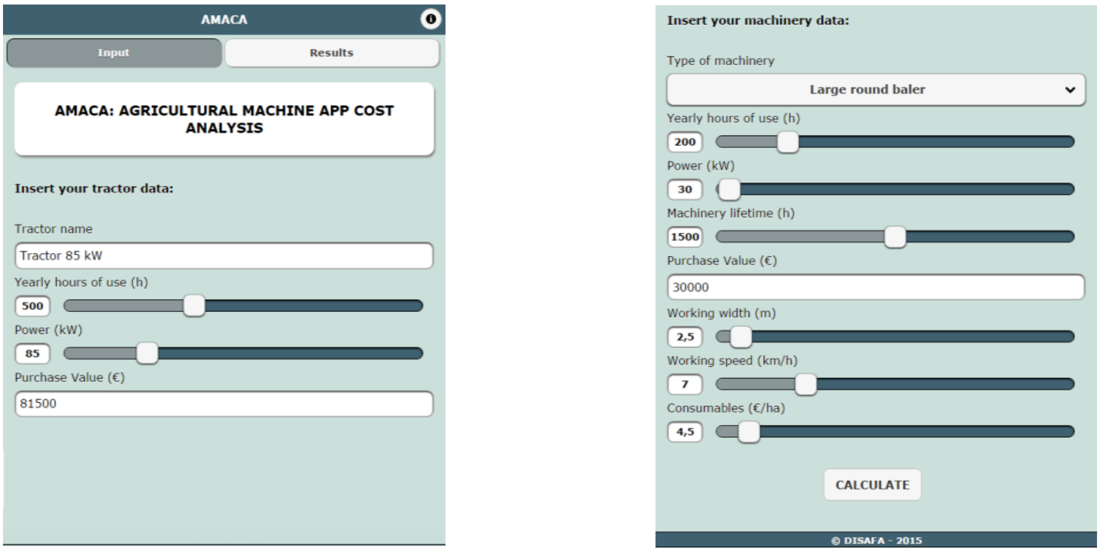
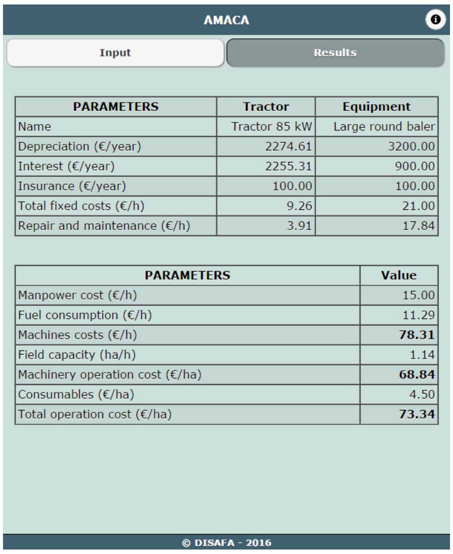


Figure 1 - Tractor input data (left) and machinery input data (right)

Regarding the machinery data section, other than selecting the machine on a drop down menu (Figure 1, right), the user must supply some input data.

The Results page (Figure 2) provides a first table with the amount of the fixed costs for the tractor and of the implement (depreciation, interest and insurance) expressed in € y^{-1}. For calculation purposes the total fixed costs and repair and maintenance costs are expressed as € h^{-1}. In the second table the costs refer to both the tractor and the equipment. The hourly and hectare operations costs are reported at the end of the page.



PARAMETERS	Tractor	Equipment
Name	Tractor 85 kW	Large round baler
Depreciation (€/year)	2274.61	3200.00
Interest (€/year)	2255.31	900.00
Insurance (€/year)	100.00	100.00
Total fixed costs (€/h)	9.26	21.00
Repair and maintenance (€/h)	3.91	17.84

PARAMETERS	Value
Manpower cost (€/h)	15.00
Fuel consumption (€/h)	11.29
Machines costs (€/h)	**78.31**
Field capacity (ha/h)	1.14
Machinery operation cost (€/ha)	**68.84**
Consumables (€/ha)	4.50
Total operation cost (€/ha)	**73.34**

Figure 1 - Results page

An application of AMACA concerns the cost comparison among different field operations. An example is given on different tillage systems, whereas a traditional ploughing using a moldboard plow, a chisel plow and a harrowing with a tandem disk harrow were considered. Table 1 lists the rest of the input machine parameters used for the tillage comparison with the AMACA program.

Table 1 - Operating machines characteristics

	Operating machine		
	Moldboard plow	Chisel plow	Tandem disk harrow
Use (h y^{-1})	80	80	80
Lifetime (h)	2,000	2,000	2,000
Purchase value (€)	14,000	5,000	30,000
Tractor power requirement (kW)	60	35	50
Working width (m)	2	5	5
Working speed (km h^{-1})	5	7	7

With these parameters AMACA produced the results shown in Figure 2.

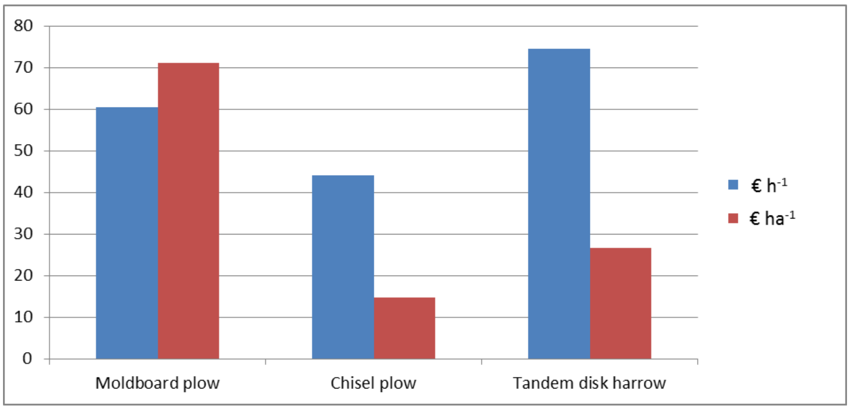


Figure 2 - Unit cost of different tillage types

This unpretentious example may address the user to choice the most economic operation in function of his operative conditions: in fact, while the traditional ploughing with the moldboard plow produces higher costs for unit of surface, the highest hourly costs are evident for the tandem disk harrow.

4. Conclusions

The customer-driven QFD approach to develop the web mobile app AMACA was implemented in order to link the user expectations with the design characteristics of the app. The AMACA app is free, readily available, and does not require any installation on the end users' devices. It is a cross-platform application meaning that it operates on any device through a web interface and major browsers support it. The results can be sent via e-mail to the operator, who can make subsequent calculations of the sensitivity by varying some parameters (fuel price, interest rate, field capacity, the power of the tractor coupled to the machine). AMACA can support the decisions on whether to purchase a new equipment/tractor (strategic level), the use of own machinery or to hire a service, and also to select the economical appropriate cultivation system (tactical level). However, it is necessary to have reliable input information, and thus detailed data may be obtained using telemetry devices and monitoring systems installed on tractors (Mazzetto, Calcante, and Salomoni 2009; Sørensen and Bochtis 2010), but only the active participation of farmers may really improve the tool capabilities. This is an issue of further research and development of the app.

References

ASABE. 2009. "D497.6: Agricultural Machinery Management Data." In ASABE Standards, St. Joseph, Mich.:ASABE.

Bochtis Dionysis D., Claus G.C. Sørensen, and Patrizia Busato. 2014. "Advances in Agricultural Machinery Management: A Review." Biosystems Engineering 126: 69–81.

Buckmaster Dennis R. 2003. "Benchmarking Tractor Costs." Applied Engineering in Agriculture 19(2): 151–54.

Busato Patrizia, and Remigio Berruto. 2014. "A Web-Based Tool for Biomass Production Systems." Biosystems Engineering 120(2006): 102–16.

Carnevalli Jose A., and Paulo Cauchick Miguel. 2008. "Review, Analysis and Classification of the Literature on QFD-Types of Research, Difficulties and Benefits." International Journal of Production Economics 114(2): 737–54.

Chan Lai Kow, and Ming Lu Wu. 2002. "Quality Function Deployment: A Literature Review." European Journal of Operational Research 143(3): 463–97.

Mazzetto F., A. Calcante, and F. Salomoni. 2009. “Development and First Tests of a Farm Monitoring System Based on a Client-Server Technology.” In Precision Agriculture 2009 - Papers Presented at the 7th European Conference on Precision Agriculture, ECPA 2009, , 389–96.

Sørensen C.G., and D.D. Bochtis. 2010. “Conceptual Model of Fleet Management in Agriculture.” Biosystems Engineering 105(1): 41–50.

Xin Jiannong et al. 2015. “Delivering Knowledge and Solutions at Your Fingertips: Strategy for Mobile App Development in Agriculture.” Agricultural Engineering International: CIGR Journal 2015: 317–25.